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THE EFFECT OF PROBLEM-SETTING QUESTIONS ON RATE AND AMOUNT OF LEARNING IN PROGRAMING TEACHING MACHINES.

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THIS STUDY WAS AN EXPERIMENTAL COMPARISON OF TWO METHODS OF PROGRAMING TEACHING MACHINES. THE BASIC RESEARCH HYPOTHESIS WAS THAT SUBJECTS WHO USED TEACHING MACHINE PROGRAMS WITH EXPOSITORY PRESENTATIONS INTRODUCED BY PROBLEM-SETTING QUESTIONS WOULD LEARN AND RETAIN MORE INFORMATION AND WOULD LEARN MORE RAPIDLY THAN SUBJECTS WHO USED TEACHING MACHINE PROGRAMS WITH EXPOSITORY PRESENTATIONS ONLY. SUBJECTS WERE 96 EIGHTH-GRADE STUDENTS. IT WAS FOUND GENERALLY THAT THE USE OF PROBLEM-SETTING QUESTIONS TO INTRODUCE THE EXPOSITORY PRESENTATIONS IN TEACHING MACHINE PROGRAMS NEITHER INCREASES OR DECREASES THE RATE OF LEARNING OR THE AMOUNT OF INFORMATION LEARNED AND RETAINED. (LP)

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FINAL REPORT

THE EFFECT OF PROBLEM-SETTING QUESTIONS ON RATE AND AMOUNT OF LEARNING IN PROGRAMMING TEACHING MACHINES

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CHAPTER I

INTRODUCTION

Statement of the Problem

A major problem throughout education is the increasing of efficiency and economy in learning. The monies of a number of national foundations and the energies of many eminent educators are being expended in ever-increasing amounts to achieve greater efficiency and economy in learning in view of the exigencies of a world seemingly entering the "age of space." One product of this concern for education has been a renewed interest in the development of devices which may relieve the teacher of many routine aspects of instruction--devices which are variously called learning, teaching, or self-instructional machines.

Porter (17)* has delineated the role of the teaching machine in education as a means of preserving the technological advances in disseminating information while simultaneously reinstating some of the advantages of face-to-face teaching. The teaching machine can also be used to test answers to questions of long standing in education. This study treated such a question, the use of problem-setting questions. In recognition of the "major psycho-educational

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*Numbers in parentheses refer to numbered references in the bibliography; those after the colon are page numbers.

issue" of individual differences as raised by Pressey (18), this study also investigated the effectiveness of this procedure with above- and below-average subjects.

Purpose

The purpose of this study was to determine experimentally the effect of using problem-setting questions in teaching machine programs on both rate and amount of learning. The study was intended to answer three basic questions: Does the use of problem-setting question in a teaching machine program increase the rate of learning? Does the use of such questions in a teaching machine program increase the amount of information learned and retained? Is there a relationship between this use of problem-setting questions and the ability levels of subjects?

Theoretical Basis of the Hypotheses

One of the earlier psychologists to recognize the student's need for a particular set was Edward Thorndike (24:26) who compared the development of a set to the Herbartian step of preparation, to McMurry's aim for the pupil, and to Dewey's doctrines of a felt need and the problem-solving attitude. Dewey (5:14-15) did not use the term "set," but he did emphasize the necessity for recognition of a problem to give direction to thought. Hartman (8:326) and Jordan

(11:107) also noted the need for mental set to give direction and organization to thought.

One method of developing a mental set favorable to the efficient and successful solution to a problem is the use of questions to establish the set, i.e., problem-setting questions. Seagoe (22:15) advised would-be teachers that questions could very well serve such a purpose by focusing attention on the main points being studied.

Research evidence bears out the philosophy expressed above. Reed (20) found that a set to learn significantly increased both rate of learning and the degree of retention of learned material. Hunter (10) investigated the effects of set on problem solving. His results showed clearly that the more specific the set the easier a problem was to solve.

Gagne and Bolles (6), reporting in Automatic Teaching: The State of the Art, noted that it is important for a student to be set for learning. They suggest that rather than to begin with the major objectives as a problem, it should be more effective to set each small problem in turn until the major objective is accomplished.

Many psychologists relate the concept of set to another psychological factor, that of "rigidity." Although rigidity as a personality factor is still debated by psychologists and, like set, has different meanings to different students, psychologists who have followed the work of Luchins (14) are giving substance to the concept of rigidity such

that the term can be defined and the rigid personality can be described. Using his well-known "water jar" technique, Luchins divided subjects into categories that could be described as rigid and non-rigid or flexible. The rigid personality identified by Luchins' test was highly susceptible to set in terms of accepting a plan or formula for action and applying this formula appropriately and inappropriately.

Several investigators have been interested in the effect of rigidity upon problem-solving ability. Cowen (3) found that rigidity produced a strong negative effect upon a subject's ability to solve problems requiring different methods of approach. Solomon (23) conducted a series of tests to determine the relationship between rigidity and the use of the scientific method in solving problems concluding that rigidity inhibits the functional use of that method. Because of the relationship between rigidity and set, an examination of possible interaction between rigidity and the use of problem-setting questions was another aspect of this study.

Related Research

The use of problem-setting questions in various methods of communication in the classroom--lectures, textbooks, films, and filmstrips--has received wide usage at many levels of the educational process. Failing to locate relevent research on the use of problem-setting questions

in textbooks and lectures, personal correspondence with several textbook authors whose texts made extensive use of such questions was used to attempt to determine the basis for using such questions. Replies indicated a total lack of a research base for the use of problem-setting questions in the several texts. This use in both textbooks and lectures seems to be based entirely upon an intuitive approach.

In the audio-visual media, however, a limited amount of research has been undertaken. Michael and Maccoby (16) used questions at various points during the showing of an educational film in a study investigating the effects of overt and covert participation and of the effects of feedback of the correct answers to the subject. The results of this investigation showed distinct gains due to feedback and an increased learning of all practiced items. However, it could not be concluded that the use of questions provided motivation toward learning.

Using a different audio-visual medium, Butts (2) found a negative result with respect to the use of questions as captions for still pictures in a filmstrip. In his study, Butts used declarative, imperative, and interrogative captions as the verbal elements in presenting still pictures. The results showed declarative and imperative captions to be superior to interrogative captions on the first test after treatment and on the retest given two weeks later.

Kurtz, Walter, and Brenner (13) investigated the use

of questions in an educational film presentation. The investigators prepared six versions of two different films to provide a control version, a repetition version, and versions having "persistent" and "medium" questions and statements. Statements and questions were designed to cover the same material. Active participation was achieved in the question versions by instructing the subjects to write their answers.

The results of this investigation showed all of the five modified versions of the films to be superior to the unmodified control version, but the ordering of these versions was inconsistent. The study demonstrated that the simplest and cheapest method of increasing learning with a motion picture was repetition of use. Because the use of questions or statements was approximately as effective as repetition, it should be noted that viewing the film twice requires twice as much time and requires this time of all students whether they need the second showing or not.

Lumsdaine and May (15) prepared four versions of a film on the heart and circulation for use with matched groups. An unmodified version was used as a control, while the other versions provided questions before, after, and both before and after each unit of content in the film. The versions using "participation" questions occurring before the presentation of each unit gave significant gains over the control version. The version using "motivation" questions presented after the unit of content was developed also produced a gain

over the control version, but the difference was not significant. The investigators indicated that their design may have reduced the significance of their findings and suggested that with film scripts specifically designed for the purpose the use of questions would contribute appreciably more to learning.

The research of Lumsdaine and May stimulated Kantor (12) to design a study using questions in an educational motion picture as introductory devices and as review devices. Three versions of the film were prepared. The control version consisted of the film in its original format, while the experimental versions used inserted questions before and after the presentation of each unit of content.

Kantor found no significant pattern in his results because the three versions varied randomly in effectiveness. He concluded that inserted questions, whether used before or after the discussion, do not significantly aid learning or retention either for the group as a whole or for selected subgroups.

It should be noted that like his predecessors Kantor investigated the use of questions in a teaching program--a motion picture--which had not been originally designed and scripted for the integrated use of questions for any purpose. Because he had complete control over the sound track, Kantor's study was more sophisticated in its design than those studies of earlier investigators. Nevertheless, Kantor also was

bound by the original design of the visual program to the insertion of questions at places in the film in which these questions would not interfere with the original plan of presentation.

In summary, the use of questions for improving the amount and/or rate of learning has occurred to a number of investigators. The research on the use of questions as other than a means for testing or evaluation considered the use of such questions only in motion pictures and filmstrips. The results of this research seem inconsistent with some of the investigators unconvinced that their results were accurate suggesting that a program specifically designed for the use of such questions would produce significantly greater learning.

Hypotheses

The basic research hypothesis for this study was that subjects who used teaching machine programs specifically designed for the use of problem-setting questions to introduce the expository presentations (Group Q) would learn more information, learn more rapidly, i.e., would require fewer repetitions for learning, and would retain more information than subjects who used teaching machine programs with expository presentations alone (Group E).

Because research using programmed information with subjects of varying ability (Wise (27); Gibson (7)) suggests that below-average subjects may benefit most from such a

program, a related hypothesis was that the greatest difference between Group Q and Group E for both immediate and retained learning would occur in the lowest third of the IQ distribution (Groups Q_3 and E_3).

As reported earlier, both Solomon and Cowen found that the disposition to accept and retain set which characterizes the personality factor of rigidity interfered with problem-solving situations in which economical solutions required different methodology from problem to problem. In the programs designed for this study, each problem was discrete from those that came before or after. However, the formula for action in the programs using questions was essentially fixed: Read the question and immediately identify the problem, read the answer to that problem, apply this knowledge to a test question, and check the answer. Because this approach to the problem was essentially fixed throughout the question-type program, a second related hypothesis was that the use of problem-setting questions in teaching machine programs would take advantage of Einstellung in subjects, i.e., that subjects with high rigidity indexes who used teaching machine programs with expository presentations introduced by problem-setting questions (Group Q_r) would learn more information and retain more information than subjects with high rigidity indexes who used teaching machine programs with expository presentations alone (Group E_r).

The seven specific hypotheses for testing were:

1. On a test for immediate recall, the mean gain of Group Q significantly exceeds the mean gain of Group E.

2. On a test for delayed recall, the mean gain of Group Q significantly exceeds the mean gain of Group E.

3. The mean number of repetitions required for completion of the programs by Group E significantly exceeds the mean number of repetitions required by Group Q.

4. On a test for immediate recall, the difference between the means of the gains of Group Q_3 and Group E_3 significantly exceeds the difference between the means of the gains of Group Q_2 and Group E_2 (average subjects) and the difference between the means of the gains of Group Q_1 and Group E_1 (superior subjects).

5. On a test for delayed recall, the difference between the means of the gains of Group Q_3 and Group E_3 significantly exceeds the difference between the means of the gains of Group Q_2 and Group E_2 and the difference between the means of the gains of Group Q_1 and Group E_1.

6. On a test for immediate recall, the mean gain of Group Q_r significantly exceeds the mean gain of Group E_r.

7. On a test for delayed recall, the mean gain of Group Q_r significantly exceeds the mean gain of Group E_r.

CHAPTER II

METHOD

Preliminary Considerations

Content and level. The content area selected for use in this study was junior high school general science, eighth grade level. This selection was made for the following reasons:

1. The area of general science provided a number of opportunities for the selection of units of content which were factual in nature and which developed readily in a step-by-step fashion.

2. Having been in the junior high school for a year, eighth grade pupils were no longer in a novel situation.

3. Eighth grade pupils could be expected to have very little previous information on several of the units of content. This would not be true of ninth grade pupils.

4. The eighth grade teachers were very receptive to the experiment.

5. Experience with pupils at this level and training and experience in teaching general science was also a consideration.

Choice of teaching machine. Another important consideration was the choice of a teaching machine with which to present the programs. A prototype using paper tapes for the program presentation and for recording the subject's responses was designed and constructed. Although the machine functioned well, two serious disadvantages made the use of such a machine undesirable. First, the time and cost of producing enough

machines for use with classes of 30 or more subjects at one time was prohibitive. Second, duplicating lengthy programs in tape form in sufficient quantity for class use was equally uneconomical with the available facilities.

An inspection of a number of commercially available programs made evident that many of them have been released as programmed texts and that many other programs are in such a form that they could be presented as programmed texts with little or no modification. Further consideration of the main problem being studied indicated that a modification of the Crowder TutorText type of programmed text would serve to make available the data needed to test the several hypotheses. A scrambled book of this type provided certain advantages over other types of teaching machines:

1. Scrambled books could be produced in quantity by standard duplicating methods.

2. The cost of producing enough copies for use with classes of 30 to 40 subjects would not be excessive.

3. The use of an answer sheet with the scrambled book would provide the same record of the subject's responses that would be provided by a device using tapes and would provide it in an even easier form with which to work when tabulating data.

4. Subjects would not have to perform any tasks that they were not already accustomed to doing, i.e., locating assigned pages in a book, reading for information, and writing answers to questions.

However, the scrambled book also presented several disadvantages:

1. A subject could loss his place rather easily and could waste a significant amount of time in relocating the page.

2. Unlike the mechanized devices for presenting a program, the scrambled book would not preclude opportunities to cheat. The subject could easily erase previous answers or look back or ahead to get the right answer.

3. A scrambled book could require more time in locating the next frame than would be needed if various other types of teaching machines were used.

Because the first two disadvantages seemed to be the most important, attention was given to methods or procedures which could reduce the significance of these disadvantages. A flow chart was prepared which made it possible to locate the last page on which a subject had been working, thus reducing to a minimum the time lost in returning to the place in the program. To control cheating, emphasis was placed on following all instructions on a given page before the subject turned to the next page and upon close supervision by the classroom teacher as well as by the investigator.

The practical advantages of a scrambled book greatly outweighed the disadvantages, so the scrambled book form of teaching machine was adopted for use in this study.

Designing the Programs

The program design had to meet two primary requirements. The first requirement was that of providing a learning environment which could be expected to produce data that would be usable in testing the basic research hypothesis. The major concern, the amount of learning resulting from each treatment, necessitated only that a sufficient number of

concepts be developed to provide a wide distribution of scores on the post-tests. With this requirement in mind, courses of study and current textbooks were surveyed to determine topics for programming.

Two factors influenced the decision to use the topics Light and Color. First, experience with adult students as well as with junior high school pupils indicated that a meager initial knowledge of these topics could be anticipated. Second, the content included in the texts and courses of study could be tailored toward presentation as a complete unit in three 45-minute class periods.

The second requirement was that the steps in the programs be sufficiently large that a number of repetitions would be required for completion. It was immediately recognized that this requirement was contrary to recommended programming principles according to the school of thought led by Skinner and described by Holland (9). However, this approach to programming as practiced by Skinner and his followers is by no means universally accepted. Rigney and Fry (21) suggest that a "pall" effect may set in reducing the amount of learning being induced in the student. Too many too-easy steps may induce boredom and a possible feeling of insulted intelligence with accompanying reduction of learning from the program. These writers suggest also that the pall effect may become more pronounced as the novelty of a teaching machine falls off with use.

Pressey (19) indicates that substantial difficulty in self-instructional items has proved valuable. In addition, he contends that a program can contribute to learning by demonstrating the error in many plausible though incorrect answers. Amsel (1) is yet another psychologist who questions the use of a frame of reference for programming in which the opportunity for error is minimized.

These steps were followed in constructing the programs:

1. A content outline was developed for each of the topics.
2. From this content, a segment was chosen for elaboration into a program.
3. A rough draft was prepared and used with a subject.
4. The trial program was revised and again used with a subject.
5. After other such trials and revisions, a final version was written which seemed to incorporate the characteristics needed to produce effective learning with the ability to generate the data needed to test the basic hypotheses. This version was then produced in both Form E, the expository form, and Form Q, the form with problem-setting questions.
6. Form E was submitted to a jury with instructions to study the frames presenting new information and to prepare a problem-setting question for each. The questions devised by the jury were compared with those devised by the author, and the latter were modified as needed to fit the recommendations of the jury.

Excerpts from Form Q of Light are presented in the Appendix.

Constructing the Test

The content outlines used in writing the programs provided the items of information which served as the basis for constructing a test for use as both pre-test and post-test. Because specific factual information was taught by the programs, this type of information was required by the test. Constructed-response questions were used almost entirely so that the subject could demonstrate with a minimum opportunity for guessing his ability to remember the factual information he had learned from the programs.

After the test had been used with several subjects and revised, it was administered to a ninth grade class for evaluation. A split-half reliability coefficient of .84 indicated that the test should be a satisfactory measure. Subsequent use as a post-test following treatment with the scrambled texts showed a split-half reliability coefficient of .99. Reliability was determined using a method of computation described by Cronbach (4:66).

Test validity could not be determined by computational means. However, in discussing validity of achievement tests, Travers (25:149) uses the term validity by definition to describe a test which presents test problems which can be solved or answered only by the information which was taught. Because this description fits exactly the test used for pre-test and post-test purposes, this test can be classed as valid by definition.

Subjects

The subjects for this experiment were pupils in the eighth grade in Binford Junior High School, Bloomington, Indiana. From the original population of 227 pupils, a final sample of 96 subjects was constituted.

Procedure

Assignment of treatments. Through the use of a table of random numbers, subjects from the population for whom an Otis IQ score had been entered in the school records were assigned to treatment Group Q or to treatment Group E. An inspection of class assignments of these subjects showed that both treatments were nearly equally represented in each class section. Because the treatment was to be carried out within the framework of existing class sections and periods, those pupils with incomplete data who were not to be subjects in the experiment were arbitrarily assigned to treatments to allow them to work along with their classmates.

Pre-test. Two days prior to the beginning of treatment, the pre-test was administered by the regular classroom teachers to those members of the population who were present on that day. Subjects were instructed to answer the questions to the best of their ability. The several subjects who were absent on the day the pre-test was given were automatically dropped from the sample because of incomplete data.

Treatment. At the beginning of the treatment, books and answer sheets were distributed according to the random assignment previously determined. Subjects were instructed in the over-all procedure through the use of a demonstration scrambled book made from large sheets of white tag board. After the demonstration was completed, those subjects who still had questions relative to the use of the book and answer sheets were given an opportunity to become certain of the procedure.

Subjects were instructed to write their names on the answer sheets, and after a suitable time the command to begin work was given. The starting time was noted so that a total elapsed time could be determined for each subject.

At the end of the work period all books and answer sheets were collected, and the ending time was recorded. On the following class period books and answer sheets were again distributed and the starting time recorded. As each subject completed the treatment, his completion time was recorded.

Post-test$_1$. The first post-test was administered by the regular teachers during the second class period following completion of the treatment. Subjects were again instructed to do their best in answering the questions.

Post-test$_2$. After an interval of six weeks, the post-test was again administered by the classroom teachers.

Test for rigidity. The test for rigidity was given to the several class sections by the investigator. The test

began with a set of three puzzles used to provide instruction in solving the problems followed by eleven test puzzles presented with two minutes being allowed for the solution of each problem.

To insure independent work, subjects were provided with special answer sheets which were folded in half to make a cover to hide their answers. The instructions given during the practice session, reminders interspersed among the remaining puzzle presentations, and close surveillance by the investigator and the teachers served to maintain a high degree of security, thus greatly reducing the possibility of error due to communication among subjects.

Treatment of the Data

Preliminary treatment of the data included division of the subjects into thirds to provide superior, average, and below average subgroups. Inspection of the data revealed that dividing the distribution five points above and below the mean IQ of about 105 would produce nearly equal thirds.

The results of the rigidity test were examined and the median determined to define those subjects to be classified as rigid. The median fell just above the division point between indexes of 5 and 6, thus those subjects having indexes of 6 or higher were classified as rigid, and subjects having indexes of 5 or lower were classified as flexible.

The subjects remaining after elimination of those with incomplete data were distributed among the cells of a 3x2x2 factorial. The number of subjects for each cell was determined by the cell with the smallest number. With eight subjects in that cell, subjects in other cells were cast out at random until a final sample of 96 subjects was obtained for the 12 cells.

The data for treatment, IQ, and rigidity were entered in the factorial for analysis of variance, and the results were interpreted using the five per cent level of probability as the level at which the null hypotheses would be rejected. A summary of the analysis of variance for the gains from each post-test is given in the Appendix.

Means were calculated for the repetitions required by the two treatment groups, and the difference between the means was tested using the *t*-test described by Walker (26: 288). The results of this and the other analyses are presented in Chapter III.

CHAPTER III

RESULTS

The purpose of this study was to determine experimentally the effect of using problem-setting questions in teaching machine programs on rate and amount of immediate and retained learning. In addition, this study investigated the relationship between this use of questions and the amount of information learned and retained by subjects at three levels of mental ability. A further purpose was to determine whether the personality factor of rigidity was related to the use of problem-setting questions. Seven hypotheses were formulated for testing; the findings for each are presented in this chapter.

Results of the Basic Research Hypothesis

Hypothesis I. Hypothesis I predicted that subjects who used programs with problem-setting questions would have a mean gain from pre-test to post-test$_1$ which would significantly exceed the mean gain of subjects who used programs without such questions. Table 1 presents the means of the pre-test scores, post-test$_1$ scores, and gains from pre-test to post-test$_1$ for Group Q and Group E.

TABLE 1. MEANS FOR PRE-TEST SCORES, POST-TEST$_1$ SCORES, AND GAINS FROM PRE-TEST TO POST-TEST$_1$ FOR GROUP Q AND GROUP E

Group	Pre-test mean	Post-test$_1$ mean	Mean gain
Q	10.00	32.25	22.25
E	9.00	30.83	21.83
		Difference	.42

Table 1 shows that Group Q made a gain of 22.25 from a pre-test mean of 10.00 to a mean of 32.25 on post-test$_1$. Group E had a mean gain of 21.83 from a mean of 9.00 to a mean of 30.83 on these tests. The resulting difference of .42 between the means of the gains was found to be not significant in the statistical analysis. Table 2 presents a summary of the analysis of variance for the gains of Group Q and Group E on the first post-test.

TABLE 2. SUMMARY OF THE ANALYSIS OF VARIANCE FOR GAINS OF GROUP Q AND GROUP E ON POST-TEST$_1$

Source of variation	SS	df	MS	Error MS
Treatments	4.1667	1	4.1667	68.5476
	F = .061	P > .05		

Table 2 shows that the F for Groups Q and E on post-test$_1$ was .061 which is not significant at the five per cent level of confidence. Hypothesis I was not supported by these findings.

Hypothesis II. Hypothesis II predicted that subjects who used programs with problem-setting questions would have a mean gain from pre-test to post-test$_2$ which would significantly exceed the mean gain of subjects who used programs without such questions. The means of the pre-test scores, post-test$_2$ scores, and gains from pre-test to post-test$_2$ for Group Q and Group E are presented in Table 3.

TABLE 3. MEANS FOR PRE-TEST SCORES, POST-TEST$_2$ SCORES, AND GAINS FROM PRE-TEST TO POST-TEST$_2$ FOR GROUP Q AND GROUP E

Group	Pre-test mean	Post-test$_2$ mean	Mean gain
Q	10.00	27.81	17.81
E	9.00	27.06	18.06
		Difference	.25

Table 3 shows that Group Q had a mean gain of 17.81 from the pre-test mean of 10.00 to the second post-test mean of 27.81. Group E had a mean gain of 18.06 from a mean of 9.00 on the pre-test to 27.06 on the second post-test. The difference of .25 between the means is even smaller than the

similar difference on post-test$_1$ and in the reverse direction. Table 4 presents a summary of the analysis of variance for the gains of Group Q and Group E on post-test$_2$.

TABLE 4. SUMMARY OF THE ANALYSIS OF VARIANCE FOR GAINS OF GROUP Q AND GROUP E ON POST-TEST$_2$

Source of variation	SS	df	MS	Error MS
Treatments	1.5	1	1.5	69.5
F = .022 P > .05				

Table 4 shows that the F for Group Q and Group E on post-test$_2$ was .022 which is not significant at the five per cent level.

Hypothesis III. This hypothesis predicted that subjects who used programs with problem-setting questions would require fewer repetitions to complete the programs than would subjects who used programs without such questions. The experimental evidence did not support this hypothesis. Table 5 presents a comparison of the means of the repetitions needed by Group Q and Group E to complete the programs.

Table 5 shows that subjects in Group Q had a mean of 2.89 repetitions while subjects in Group E completed the programs with a mean of 3.29 repetitions. Applying the "t" test to the difference of .40 gave a "t" of .23 which is not significant at the five per cent level.

TABLE 5. COMPARISON OF THE MEAN NUMBER OF REPETITIONS FOR COMPLETION OF PROGRAMS BY GROUP Q AND GROUP E

Group	Mean number of repetitions
Q	2.89
E	3.29
	Difference .40 t = .23 P > .05

Results of the Related Hypotheses

Hypothesis IV. Hypothesis IV predicted that on a test for immediate recall the use of problem-setting questions would be most effective with subjects in the lower third of the IQ distribution. Table 6 presents the means of the pre-test scores, post-test$_1$ scores, and gains from the pre-test to post-test$_1$ for the first, second, and third thirds of Group Q and Group E.

Table 6 shows that the difference of .06 between the means of the gains for the first third of Group Q and Group E favored Treatment E but was very small. The differences between the means of the gains of the average and below average groups were .38 and .94, respectively, with the differences favoring Treatment Q.

TABLE 6. MEANS OF THE PRE-TEST SCORES, POST-TEST$_1$ SCORES, AND GAINS FROM PRE-TEST TO POST-TEST$_1$ FOR THE FIRST, SECOND, AND THIRD THIRDS OF GROUP Q AND GROUP E

Subgroup	Pre-test mean	Post-test$_1$ mean	Mean gain
Q_1	14.50	42.19	27.69
Q_2	9.63	33.81	24.19*
Q_3	5.88	20.75	14.88*
E_1	13.44	41.19	27.75
E_2	8.00	31.81	23.81
E_3	5.56	19.50	13.94
Differences	$Q_1 - E_1 = -$	.06	
	$Q_2 - E_2 =$	.38	
	$Q_3 - E_3 =$	.94	

*Discrepancies of .01 in the values for Q_2 and Q_3 result from rounding these values to the nearest hundredth.

Table 7 presents a summary of the interaction of IQ with treatment on post-test$_1$.

TABLE 7. SUMMARY OF THE INTERACTION OF IQ WITH TREATMENT ON POST-TEST$_1$

Source of variation	SS	df	MS	Error MS
IQ with treatment	4.0209	2	2.0104	68.5476
$F = .029$ $P > .05$				

Table 7 shows that the interaction of IQ with treatment on the first post-test produced an F of .029 which is not significant at the five per cent level of confidence.

Hypothesis V. The fifth hypothesis predicted that on a test for delayed recall the use of problem-setting questions in teaching machine programs would be most effective with subjects in the lower third of the distribution of mental ability. Table 8 presents the means of the pre-test scores, post-test$_2$ scores, and gains from pre-test to post-test$_2$ for the first, second, and third thirds of Group Q and Group E.

TABLE 8. MEANS OF THE PRE-TEST SCORES, POST-TEST$_2$ SCORES, AND GAINS FROM PRE-TEST TO POST-TEST$_2$ FOR THE FIRST, SECOND, AND THIRD THIRDS OF GROUP Q AND GROUP E

Subgroup	Pre-test mean	Post-test$_2$ mean	Mean gain
Q_1	14.50	38.38	23.88
Q_2	9.63	25.50	15.87
Q_3	5.88	19.56	13.68
E_1	13.44	37.62	24.18
E_2	8.00	28.06	20.06
E_3	5.56	15.50	9.94
Differences		$Q_1 - E_1 = -.30$	
		$Q_2 - E_2 = -4.19$	
		$Q_3 - E_3 = 3.74$	

Table 8 shows that the differences between the means of the gains of the superior, average, and below average subgroups of Group Q and Group E were .30, 4.19, and 3.74 in that order. The difference of 4.19 for the average subgroup favored Treatment E while the difference of 3.74 for the below average subgroup favored Treatment Q. The cancelling effect of these opposite trends is evident in the results of the analysis of variance. Table 9 presents a summary of the interaction of IQ with treatment on post-test$_2$.

TABLE 9. SUMMARY OF THE INTERACTION OF IQ WITH TREATMENT ON POST-TEST$_2$

Source of variation	SS	df	MS	Error MS
IQ with treatment	252.0797	2	126.0398	69.5
	F = 1.814	P > .05		

Table 9 shows that the interaction of IQ with treatment on the second post-test produced an F of 1.814 which was not significant at the five per cent level.

Hypothesis VI. The sixth hypothesis predicted that on a test for immediate recall the mean gain of rigid subjects who used programs with problem-solving questions would exceed the mean gain of rigid subjects who used only programs with expository presentations. Table 10 presents the means

of the gains of rigid and flexible subjects for Treatment Q and Treatment E on post-test$_1$.

TABLE 10. MEANS OF THE GAINS OF RIGID AND FLEXIBLE SUBJECTS FOR TREATMENT Q AND TREATMENT E ON POST-TEST$_1$

Treatment-group	Mean
Q-rigid	21.8
Q-flexible	22.7
E-rigid	21.9
E-flexible	21.8

Table 10 shows that the mean gain for rigid subjects with Treatment Q was 21.8 and the mean gain for rigid subjects with Treatment E was 21.9. The difference of .1 between these means is in the reverse direction from that predicted by Hypothesis VI, but it is too small to be of significance. A summary of the interaction of rigidity with treatment is presented in Table 11.

TABLE 11. SUMMARY OF THE INTERACTION OF RIGIDITY WITH TREATMENT ON POST-TEST$_1$

Source of variation	SS	df	MS	Error MS
Rigidity-treatment	7.0418	1	7.0418	68.5476
F = .103 P > .05				

Table 11 shows that the interaction of rigidity with treatment on post-test$_1$ produced an F of .103 which was not significant at the five per cent level.

Hypothesis VII. This hypothesis predicted that on a test for delayed recall the mean gain of rigid subjects who used programs with problem-setting questions would exceed the mean gain of rigid subjects who used expository programs. This hypothesis was rejected at the five per cent level of confidence on the basis of the findings. Table 12 presents the means of the gains of rigid and flexible subjects for Treatment Q and Treatment E on the second post-test.

TABLE 12. MEANS OF THE GAINS OF RIGID AND FLEXIBLE SUBJECTS FOR TREATMENT Q AND TREATMENT E ON POST-TEST$_2$

Treatment-group	Mean
Q-rigid	15.0
Q-flexible	20.6
E-rigid	18.4
E-flexible	17.8

Table 12 shows that the mean gain for rigid subjects in Group Q was 15.0, and the mean gain for rigid subjects in Group E was 18.4. As in the first post-test, the difference between the means was in the direction opposite to that predicted by the hypothesis. Table 13 presents a summary of the interaction of rigidity with treatment on post-test$_2$.

TABLE 13. SUMMARY OF THE INTERACTION OF RIGIDITY WITH TREATMENT ON POST-TEST$_2$

Source of variation	SS	df	MS	Error MS
Rigidity-treatment	222.0417	1	222.0417	69.5
F = 3.195 P > .05				

Table 13 shows that the interaction F of 3.195 for rigidity with treatment is not significant at the five per cent level.

CHAPTER IV

DISCUSSION

The very small differences between the means of the gains for Group Q and Group E found in post-test$_1$ and post-test$_2$ indicate that the programs produced essentially the same results. It is evident that within the framework of this study the basic hypothesis that problem-setting questions would increase the amount of immediate and retained learning must be rejected. However, there are questions which remain unanswered by the study. Would this use of questions in programmed learning have produced a greater difference if the steps had been larger? Perhaps, because the unit of instruction was a very short paragraph, it was unnecessary to provide a question which could serve as a focal point.

Size of step is an aspect of programmed instruction which is still being debated. Should research show that the larger steps used by some programmers are more effective than smaller steps, the use of problem-setting questions might prove to be of significance when used in such programs.

A second question remains unanswered. Would the use of problem-setting questions prove to be significant if the same question were used again following the presentation as the question which tests for learning? It was felt that the problem-setting questions should generally be of the type which would require an essay form of answer, an

assumption substantiated by the responses of the jury which assisted in preparing these questions. In contrast, questions that test for learning in the program are usually of the multiple-choice or short-answer constructed-response type. The simpler forms of teaching machines place this restriction upon the question used to test for learning because the burden of decision of the correctness of his response is placed upon the learner. To make such decisions simple and clear-cut, the program asks questions such that responses can be compared with the answers supplied by the program. The use of essay questions at this point in a program would make the comparison of answers and the decision of correctness unduly difficult thus reducing the effect of reinforcement. If the same question could be used satisfactorily for setting the problem and for testing learning, the strategy proposed by this study might produce significant results.

A third question may also be asked: Would the use of questions prove to be significant if the question related to a given discussion appeared on a frame preceding the discussion instead of with the discussion? The use of participation questions in a film program was found by Michael and Maccoby to produce gains in learning. If the presentation of questions prior to and apart from the discussion should serve the same function as that served by the questions in the study indicated, perhaps additional gains would be made by subjects using such a program.

One factor in this study which was not treated statistically was the time required for completion of the programs. Table 14 presents a comparison of the average times required by Group Q and Group E and their subgroups.

TABLE 14. COMPARISON OF TIMES REQUIRED FOR COMPLETION OF PROGRAMS BY GROUP Q, GROUP E, AND THEIR SUBGROUPS

Third	Average time		Difference (Q - E)
	Q	E	
1	71.19 min.	69.25 min.	1.94 min.
2	78.81	82.93	- 4.12
3	101.62	89.75	11.87
Totals	83.87	80.65	3.22
	Over-all mean	82.26 minutes	

Table 14 shows that the average time required to complete the programs in Treatment Q was 3.22 minutes longer than the time required for Treatment E. From a practical standpoint, this difference is not enough to play a very important part in a decision for or against using a program which employs the strategy under investigation. However, Table 14 also shows that the usual positive correlation between reading ability and IQ is an important factor in programs which are lengthened by added questions. In the below average subgroup, Treatment Q required 11.87 minutes more than the time required by Treatment E for completion.

Translated into the usual 45 or 50 minute class period, this time represents about one-fourth of a period more time required by slow groups to complete Treatment Q. This added time would be highly significant to a teacher who was trying to develop a schedule for programmed instruction in a number of units or in several areas of instruction.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was an experimental comparison of two methods of programming teaching machines. The basic research hypothesis for the study was that subjects who used teaching machine programs with expository presentations introduced by problem-setting questions would learn and retain more information and would learn more rapidly than subjects who used teaching machine programs with expository presentations only. As a related problem it was hypothesized that below average subjects would benefit more from the use of problem-setting questions than would average or superior subjects. A third hypothesis was that subjects having a rigid personality would benefit more from the use of problem-setting questions than would subjects having non-rigid or flexible personalities.

To test any differences between the results of using programs with problem-setting questions and the results of using expository programs, seven hypotheses were formulated:

1. On a test for immediate recall, the mean gain of Group Q significantly exceeds the mean gain of Group E.

2. On a test for delayed recall, the mean gain of Group Q significantly exceeds the mean gain of Group E.

3. The mean number of repetitions required for completion of the programs by Group E significantly

exceeds the mean number of repetitions required by Group Q.

4. On a test for immediate recall, the difference between the means of the gains of Group Q_3 and Group E_3 significantly exceeds the difference between the means of the gains of Group Q_2 and Group E_2 and the difference between the means of the gains of Group Q_1 and Group E_1.

5. On a test for delayed recall, the difference between the means of the gains of Group Q_3 and Group E_3 significantly exceeds the difference between the means of the gains of Group Q_2 and Group E_2 and the difference between the means of the gains of Group Q_1 and Group E_1.

6. On a test for immediate recall, the mean gain of Group Q_r significantly exceeds the mean gain of Group E_r.

7. On a test for delayed recall, the mean gain of Group Q_r significantly exceeds the mean gain of Group E_r.

Programs were developed for two content areas, Light and Color, for use with eighth grade general science pupils. A test was devised for use as a pre-test and post-test and its reliability determined through use with a ninth grade class. The actual experiment began with a pre-test administered to determine the prior knowledge of the sample. After treatment with the two types of programs, a post-test was used to measure immediate learning. After an interval of six weeks, the test was administered again to test for retained learning.

Rigidity was measured with a word-puzzle test given after the second post-test. The data derived from the treatment and tests were entered into a three-dimensional factorial for statistical examination by analysis of variance.

The findings from testing the hypotheses were:

1. On tests for immediate and retained learning, there was no significant difference between the mean of the gains of the group using programs with problem-setting questions and the mean of the gains of the group using expository programs.

2. The group using programs with questions required a smaller mean number of repetitions to complete the programs compared to the mean for the group using expository programs, but the difference was not significant.

3. On tests for immediate and retained learning, there was no significant interaction among the three ability levels of IQ relative to the mean gains of subjects using programs with questions and subjects using expository programs.

4. On tests for immediate and retained learning, the mean gain achieved by rigid subjects was greater for the group using expository programs, but the difference was not significant. Among flexible subjects, a greater gain was achieved with programs using problem-setting questions, but the difference was not significant.

Conclusions

From the results found in this study, the following conclusions can be drawn:

1. The use of problem-setting questions to introduce the expository presentation in a teaching machine program has no significant effect on either immediate or retained learning.

2. The use of problem-setting questions in teaching machine programs has no significant effect upon rate of learning as measured by the number of repetitions needed for completion of the program.

3. This use of problem-setting questions has no significant interaction with the ability levels of subjects for either immediate or retained learning. However, the total time required to complete a program with questions increases with

a decrease in ability level and may be a very practical consideration with below average subjects.

4. The personality factor of rigidity has no significant interaction with the use of problem-setting questions in a teaching machine program.

Therefore the following general conclusion can be drawn: The use of problem-setting questions to introduce the expository presentations in teaching machine programs specifically designed for the use of such questions neither increases nor decreases the rate of learning or the amount of information learned and retained.

Recommendations

Several observations arose from this study which indicate possible areas for future research. The average score on the first post-test for the combined Q and E programs was 31.54. The average score after an interval of six weeks with no opportunity provided for review or further study was 27.44, a loss of 13 per cent. While no conclusions can be drawn from the data obtained for this study, this seems like a very low loss for that time interval. Further research with the types of programs used in this study, with other types of programs, and with other methods of instruction would provide comparisons which might be meaningful to educational theory or practice.

Although the use of a teaching machine as a device for gathering data proved to be highly satisfactory from the

standpoint of the ease of obtaining data as well as from the success of the programs, observations made during the treatment stage pose a number of questions. Subjects exhibited a very high degree of motivation, expressed by one subject as a desire or compulsion to "beat the book." How long can this degree of motivation be sustained? What bias is injected into the data by whatever level of novelty-effect exists for each subject, and is this bias random or directed?

A number of below-average subjects with classroom reputations for low ability, lack of ambition, uncooperative attitude, and poor achievement worked with great diligence and produced gains well above the average for their subgroups. Two of these subjects in different class sections volunteered expressions of personal satisfaction with the method of instruction stating a desire for more classwork of that nature. How long would a teaching machine and program of the type used in this study continue to motivate such a subject? Some researchers report that excessive motivation may reduce learning. Does such a condition exist with the use of the scrambled text? If so, how can motivation be controlled to produce optimum results? What would be the best method for using this device, as a day-to-day instructional aid or as a self-help device for occasional use in the many problem areas typical of most school subjects?

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APPENDIX

Light and Color

Part I, Light

We are going to study light in this lesson.

The first thing we should learn about light is that light is a form of energy. Also, the energy in light can be changed into other kinds of energy.

Turn to page 6.

2

1-A. Energy

Did you get it right this time? If so, turn to page 22.

If you made an error, turn to page 23.

3

2.

___ use the energy of sunlight to help make food.

Turn to page 19.

4

What is a luminous body?*

Anything which produces light is called a luminous body. Because the sun, a burning flashlight, a fire, all produce their own light, they can all be classed as luminous bodies. A mirror or the moon can only reflect light--they are non-luminous bodies.

Turn to page 7.

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*Questions indicated by an asterisk were found only in Form Q. The expository treatment (Form E) was identical to the program presented here except for the omission of the questions thus indicated.

Page 5

2-A. Green plants energy food

If your answers are correct, turn to page 4.

If you made an error, turn to page 12.

6

1.

We know that light is a form of ____ because we can change light into other kinds of ____.

Check your answer on page 13.

7

3.

The sun is a ____ body because it produces ____.

Check your answer on page 16.

8

From what does a green plant get energy to make food?*

Green plants make and store food. Every other living thing depends upon green plants to grow and make food. The green plants get the energy to make food from the sunlight which shines on them.

Turn to page 21.

9

3-B. Luminous

Anything which is luminous will give off its own light.

Now turn to page 30.

10

3-A.

Page

Anything which gives off its own ____ may be classed as a ___ body.

Turn to page 20.

11

1-A.

Light is a form of ____.

Check your answer on page 2.

12

What is the source of the energy used by green plants?*

Remember, light is a form of energy, and green plants use the energy from sunlight to help them make food.

Turn to page 17.

13

1. Energy energy

If your answers are right, turn to page 22.

If your answers are wrong, turn to page 15.

14

1-B. Energy

Light is a form of energy.

Now you are ready to turn to page 22 for a new lesson. Read it carefully, but don't waste time.

15

Can light energy be changed into other forms of energy?*

Light is a form of energy and can be changed into other kinds of energy. Light energy can be changed into electrical energy, heat energy, or any other form of energy.

Turn to page 11.

TABLE 15. SUMMARY OF ANALYSIS OF VARIANCE FOR POST-TEST$_1$

Source of variation	SS	df	MS	F
Treatment (QE)	4.1667	1	4.1667	.061
Rigidity (RF)	3.3749	1	3.3749	.049
IQ	3,019.6458	2	1509.8229	22.026
IQ x RF	145.6876	2	72.8438	1.063
IQ x QE	4.0209	2	2.0104	.029
QE x RF	7.0418	1	7.0418	.103
IQ x QE x RF	11.8956	2	5.9478	.087
Error	5,758.0000	84	68.5476	
Totals	8,953.8333	95		

TABLE 16. SUMMARY OF ANALYSIS OF VARIANCE FOR POST-TEST$_2$

Source of variation	SS	df	MS	F
Treatment (QE)	1.5000	1	1.5000	.022
Rigidity (RF)	150.0000	1	150.0000	2.158
IQ	2,388.8125	2	1,194.4062	17.186
IQ x RF	65.4547	2	32.7278	.471
IQ x QE	252.0797	2	126.0398	1.814
QE x RF	222.0417	1	222.0417	3.195
IQ x QE x RF	7.7364	2	3.8682	.056
Error	5,838.0000	84	69.5	
Totals	8,925.6250	95		